Postharvest Berry Drop of Seedless Berries Produced by GA Treatment in Grape Cultivar 'Kyoho' I. Relationship between Postharvest Berry Drop and Rachis Hardness

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Postharvest Berry Drop of Seedless Berries Produced by GA Treatment in Grape Cultivar 'Kyoho'

I. Relationship between Postharvest Berry Drop and Rachis Hardness

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Summary

In 'Kyoho' grapevines, compact clusters of sufficiently large, seedless berries were produced by gibberellin (GA) treatment, but the percentage berry drop when they were dropped from a height of 1 m was higher, fruit removal force (FRF) of their individual berries was smaller, and rachis hardness was larger than those of the control clusters of seeded berries. Such effects of GA were more accentuated for vigorous shoots than for moderate shoots, though not so marked as expected. Moreover, as an index of easiness of berry drop, horizontal FRF proved to be more suitable than the vertical one in consideration of the correspondence to the percentage berry drop.

When clusters of four cultivars were treated with GA at different dates around the flowering time and then harvested simultaneously, total soluble solid content (TSS), as an index of berry maturity, was higher after the earlier treatments regardless of cultivars. With the increase of TSS, however, FRF decreaed in easy-to-drop cultivars such as 'Kyoho' and 'Campbell Early', while it varied little in difficult-to-drop cultivars such as 'Muscat Bailey A' and 'Himrod'. Rachis hardness was large and still increased with TSS in the former cultivars, but in the latter cultivars it was small and varied little with TSS. Moreover, in 'Kyoho', FRF of GA-induced seedless berries decreased markedly at considerably earlier stages of berry maturity as compared with that of the seeded berries of the control clusters. From these results, it appeared that rachis hardness, rather than berry maturity, was responsible for the postharvest berry drop hastened by GA treatment. Rachis hardness was increased by GA treatment and the increase was often accompanied with an increase in the diameters of pedicel and rachis, while berry maturity was perhaps related to the softening of berry tissues.

No evolution of ethylene could be detected from GA-treated clusters of 'Kyoho'. In addition, berry drop was remarkably hastened by 80 ppm ethylene, but the abscised berries were separated from their pedicel different from the ethylene-untreated berries. Thus, ethylene was unlikely to play any role in the postharvest berry drop hastened by GA treatment.

'Kyoho' is a 4n hybrid derived from a cross of 'Sentenial' (*Vitis vinifera* L.) × 'Ishihara Wase' (*Vitis vinifera* L. × *V. labrusca* L.). The berries are very large with tough skins, firm and juicy pulp and excellent quality. The vines, however, are often too vigorous and subject to excessive shatter or the setting of shot berries, and this is especially true when grown in volcanic ash soils with heavy rainfall. To improve such unstable setting, GA application to flower clusters has been tried by many investigators (1, 2, 3, etc.) in recent years and proved to be effective in producing compact clusters of sufficiently large, seedless berries suitable for marketing. Following GA treatment, however, the pedicel and rachis increased their diameter and hardness, and the berries were easily separated from the pedicels by physical shock both at harvest and in transit, and consequently, suffered serious loss in marketability. The purpose of this study was to elucidate the cause of the postharvet berry drop following GA treatment and to develop some countermeasures. The following experiments were designed to determine the relationship of GA-induced berry drop to shoot vigour, ethylene treatment and berry maturity as affected by GA treatment time or harvesting time.

Materials and Methods

1. *Postharvest Berry Drop as Affected by GA Treatment and Shoot Vigour.*

Five-year-old 'Kyoho' grapevines grown in Fukushima Horticultural Experiment Station were used. Shoots of 35–55 cm and 60–80 cm in length (hereinafter designated as moderate and vigorous shoots, respectively) were selected on June 4, and each flower cluster was thinned on the following day leaving 14 laterals, with shoulders, some of upper laterals and cluster tip removed. The flower clusters were dipped twice into GA_3 (Kyowa Hakko Kogyo K.K.) solution at 100 ppm with 100 ppm Aerol OP as a wetting agent on the 3rd and 18th days after full bloom (June 17 and July 2, respectively). After berry set, they were thinned so as to leave the seedless berries alone, and harvested on September 22. The number of berries per cluster, average berry weight, total soluble solid content (TSS), fruit removal force (FRF), diameters of pedicel and its xylem at berry attachment and deflection angle of rachis were determined together with those of the control clusters. TSS was measured using a hand refractometer N–1 (Atago Seisakusho). FRF means the force required to detach a berry from its pedicel, and was measured with a force gauge by clamping the pedicel and pulling the berry in the direction of the axis of the pedicel or pushing the berry at a right angle to the axis of the pedicel, until the berry was separated (hereinafter designated conventionally as vertical and horizontal FRF, respectively). Deflection angle of rachis was used as an index of rachis hardness. For its determination, distal 10 cm of the rachis was placed in a horizontal position and its proximal end was fixed on a fulcrum. A wire 8 cm in length was attached to the axis of the rachis by adhesive tape and a weight of 50 g was hung from it at a distance of 10 cm from the fulcrum. Then, the angle between the horizontal line and the wire (the axis of the rachis) was measured and designated as the deflection angle of rachis (Fig. 1). In addition, numbers of berries dropped and retained when clusters were dropped from a height of 1 m were counted. In the control clusters, seeded and seedless berries were found together, so they were counted separately.

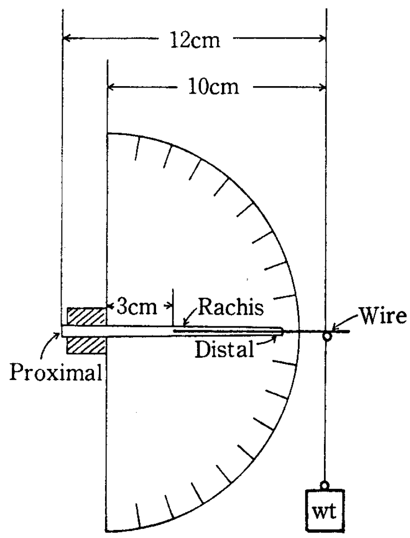

FIG. 1. Diagram of the method by which deflection angle of rachis was measured.

2. *Postharvest Berry Drop as Affected by the Time of GA Treatment.*

Seven-year-old 'Kyoho', 17–year-old 'Campbell Early' and 'Muscat Bailey A' and 3-year-old 'Himrod' grown in Tohoku University were used. Clusters of each cultivars were treated with GA as in Exp. 1 but only once on different dates before or after full bloom. All cultivars used reached full bloom on June 18 and were harvested simultaneously on August 17 together with the control clusters. In this experiment, clusters were not thinned after berry set and consequently, both seeded and seedless berries were found in a cluster regardless of GA treatment except for 'Himrod', the only seedless cultivar used. Horizontal FRF, average berry weight, number of berries per cluster, TSS, diameters of pedicel and its xylem at berry attachment, deflection angle of rachis, and diameters of rachis and its xylem at the fulcrum were measured separately for seeded and seedless berries.

3. *Postharvest Berry Drop as Affected by the Time of Harvest.*

Seven-year-old 'Kyoho' grown in Tohoku University was used. Clusters were treated with GA at full bloom on June 18, and six clusters each were sampled 8 times at regular intervals from July 27 to September 2 together with the control clusters. The measurements were the same as those in Exp. 2.

4. *Postharvest Berry Drop Induced by Ethylene.*

Three extra GA-treated clusters harvested in Exp. 1 were kept in a desiccator of 24.2 l in a 20°C room. Ethylene gas was injected into the desiccator to a concentration of 80 ppm, and the air in it was agitated by a small electric fan. The concentration of ethylene was monitored using a gas chromatograph GC–3A (Shimazu Seisakusho). Every day during the following three days, one cluster was taken out of the desiccator and ethylene gas was reinjected. The clusters taken out of the desiccator were kept at 20°C and after 15 hours, the number of berries dropped, FRF of retained berries, and TSS of both dropped and retained berries were determined. These values were also determined for the control clusters which were treated with GA but not with ethylene and kept in another 20°C room.

Three GA-treated clusters were incubated at 20°C for 4·2/3 hours in a desiccator of 24.2 l and measured for ethylene evolution by gas chromatography.

Results

1. *Postharvest Berry Drop as Affected by GA Treatment and Shoot Vigour.*

The number of berries per cluster, average berry weight and TSS: The number of berries per cluster treated with GA was 33 and the berries were all seedless and 10–11 g in weight, being little affected by shoot vigour and as large as the seeded berries of the control clusters. The control clusters produced many parthenocarpic (seedless) berries together with a small number of seeded berries different from in the average season, and the seedless berries were as small as 4 g in weight regardless of shoot vigour. TSS was little affected by shoot vigour, and a little lower for the seedless berries of GA-treated clusters than for the seeded berries of the control clusters (Table 1).

FRF and the percentage berry drop: The percentage berry drop when clusters were dropped from a height of 1 m was evidently higher for the seedless berries of GA-treated clusters than for the seeded and seedless berries of the control clusters. Moreover, it was a little higher for the vigorous shoots than for the moderate shoots regardless of GA treatment. Corresponding to the percentage berry drop, horizontal FRF was smaller for the seedless berries of GA-treated clusters than for the seeded berries of the control clusters, and it was also smaller for GA-induced seedless berries on the vigorous shoots than those on the moderate shoots, although the differences were not so marked as in the percentage berry drop. As to the control clusters, it was much smaller for the seedless berries and a little larger for the vigorous shoots. This was different from the situation in GA-treated clusters. In addition, no consistent relationship was found between the vertical FRF and the percentage berry drop, as far as GA-treated clusters were concerned (Table 2).

Development of pedicel and rachis and rachis hardness: Rachis hardness expressed by the deflection angle was markedly increased by GA treatment regard-

TABLE 1. *Effects of GA and Shoot Vigour on Number of Berries per Cluster, Average Berry Weight and Total Soluble Solid Content (TSS) in 'Kyoho'*

		Shoot Vigour^{z}	
		Moderate	Vigorous
		No. of berries per cluster	
GA^{y}		33	33
Control	Sd.^{x}	6	11
	Sl.	33	32
		Average berry weight (g)	
GA		10.9	10.6
Control	Sd.	10.7	12.1
	Sl.	4.4	4.1
		TSS (Brix %)	
GA		17.0	17.1
Control	Sd.	18.5	17.9
	Sl.	21.1	19.9

z: 35–55 (moderate) and 60–80 (vigorous) cm in length on June 4.
y: Seedless berries alone.
x: Sd. Seeded berries, Sl. Seedless berries.

TABLE 2. *Effects of GA and Shoot Vigour on Fruit Removal Force (FRF) and Percentage Berry Drop when Clusters Were Dropped from a Height of 1 m*

		Shoot vigour^{z}	
		Moderate	Vigorous
		Horizontal FRF (g)	
GA^{y}		156	147
Control	Sd.^{x}	177	206
	Sl.	117	123
		Vertical FRF (g)	
GA		296	303
Control	Sd.	321	267
	Sl.	156	155
		Percentage berry drop	
GA		61	65
Control	Sd.	20	33
	Sl.	38	43

z, y, x: Refer to TABLE 1.

less of shoot vigour, while that of the control clusters was a little increased for the vigorous shoots. With the increase of rachis hardness, the values of rachis diameter, pedicel length and diameters of pedicel and its xylem were all increased (Table 3).

TABLE 3. *Effects of GA and Shoot Vigour on Development of Rachis and Pedicel and Deflection of Rachis when a Weight of 50 g Was Hung at a Distance of 10 cm from the Proximal End of Rachis*

		Shoot vigour[z]	
		Moderate	Vigorous
		Diameter of rachis (mm)	
GA[y]		5.4	5.6
Control		4.3	4.8
		Deflection angle (degree)	
GA		7	6
Control		34	27
		Diameter of pedicel (mm)	
GA		4.1	4.3
Control	Sd.[x]	3.9	3.8
	Sl.	2.7	2.8
		Xylem diameter of pedicel (mm)	
GA		2.3	2.5
Control	Sd.	1.6	1.7
	Sl.	1.0	1.1
		Length of pedicel (mm)	
GA		9.7	8.5
Control	Sd.	8.8	7.9
	Sl.	7.1	6.8

z, y, x: Refer to TABLE 1.

2. *Postharvest Berry Drop as Affected by the Time of GA Treatment.*

The number of berries per cluster, average berry weight and TSS: Seedless berries were produced at a higher ratio by GA treatment on June 6 and 16 than by earlier or later treatments regardless of cultivars. This was especially true for the treatment on June 16, two days before full bloom, for 'Kyoho' and 'Muscat Bailey A', and on June 6, 12 days before full bloom, for 'Campbell Early' (Table 4). When

TABLE 4. *Effects of Time of GA Treatment on Number of Berries per Cluster in Four Grape Cultivars*

		Date of GA treatment[z]					
		May 27	June 2	June 6	June 16	June 24	July 6
Kyoho	Sd.[y]			2	3	12	22
	Sl.			35	57	14	1
Campbell Early	Sd.			15	44	68	68
	Sl.			64	29	2	0
Muscat Bailey A	Sd.		39	9	14	43	60
	Sl.		9	25	50	11	1
Himrod[x]		57		59	79		

z: Date of full bloom was June 18 in all cultivars.
y: Sd. Seeded berries, Sl. Seedless berries.
x: Seedless cultivar.

GA treatment was delayed, the number of seedless berries was reduced in all cultivars used, and in 'Kyoho', in particular, total number of berries was also reduced. Moreover, it was when the highest ratio of seedless berries was obtained that the average berry weight reached its maximum (Table 5). In 'Himrod', the only seedless cultivar used, GA treatment on June 16 produced a greater number of larger berries than earlier treatments. As to TSS, the earlier the time of GA treatment, the higher the values observed, regardless of seedlessness and cultivars (Table 6).

TABLE 5. *Effects of Time of GA Treatment on Average Berry Weight in Four Grape Cultivars*

		Date of GA treatment^z					
		May 27	June 2	June 6	June 16	June 24	July 6
				(g)			
Kyoho	Sd.^{y}			-	-	-	11.9
	Sl.			6.5	7.8	6.5	-
Campbell Early	Sd.			4.4	4.9	4.7	5.1
	Sl.			2.0	1.7	-	-
Muscat Bailey A	Sd.		5.3	3.7	5.2	6.7	6.8
	Sl.		2.1	2.2	4.1	3.5	-
Himrod^x		1.9		1.8	2.4		

z, y, x: Refer to TABLE 4.

TABLE 6. *Effects of Time of GA Treatment on Total Soluble Solid Content in Four Grape Cultivars*

		Date of GA treatment^z					
		May 27	June 2	June 6	June 16	June 24	July 6
				(Brix %)			
Kyoho	Sd.^{x}			-	-	-	11.6
	Sl.			17.2	14.7	13.9	-
Campbell Early	Sd.			13.5	13.0	12.7	12.5
	Sl.			15.2	14.9	-	-
Muscat Bailey A	Sd.		18.3	18.4	18.2	18.1	17.6
	Sl.		20.7	18.7	19.0	19.4	-
Himrod^x		19.2		18.8	17.0		

z, y, x: Refer to TABLE 4.

FRF, deflection angle of rachis and the development of pedicel and rachis: The earlier the GA treatment, the lower the horizontal FRF in 'Kyoho' and 'Campbell Early', regardless of seedlessness (Table 7). In addition, FRF of the seedless berries appeared to be half that of the seeded berries, and that of 'Campbell Early' appeared to be a little lower than half that of 'Kyoho'. In 'Muscat Bailey A' and 'Himrod', however, FRF was little affected by the time of GA treatment, although, in 'Muscat Bailey A', it was markedly lower for the seedless than for the seeded berries. Deflection angle of rachis was markedly small and still smaller following the earlier treatments in 'Kyoho' and 'Campbell Early', while in 'Muscat Bailey A' and 'Himrod', it was large and little affected by the time of GA treatment (Table 8). Diameters of rachis and its xylem were somewhat larger in 'Kyoho' and 'Campbell Early' following the GA treatments on June 6 to 16 and June 6, respectively, although they varied little in 'Muscat Bailey A' and 'Himrod' (Table 8). Diameters of pedicel and its xylem, however, showed no consistent change in relation to the time of GA treatment in all four cultivars (Table 9).

TABLE 7. *Effects of Time of GA Treatment on Fruit Removal Force (Horizontal) in Four Grape Cultivars*

		Date of GA treatment[z]					
		May 27	June 2	June 6	June 16	June 24	July 6
		(g)					
Kyoho	Sd.[y]			-	-	-	219
	Sl.			105	120	134	-
Campbell Early	Sd.			97	109	120	123
	Sl.			46	50	-	-
Muscat Bailey A	Sd.		139	123	151	144	142
	Sl.		99	86	107	99	-
Himrod[x]		63		65	59		

z, y, x: Refer to TABLE 4.

TABLE 8. *Effects of Time of GA Treatment on Development and Deflection of Rachis in Four Grape Cultivars*

	Date of GA treatment[z]					
	May 27	June 2	June 6	June 16	June 24	July 6
	Rachis diameter (mm)					
Kyoho			5.9	5.6	4.9	4.8
Campbell Early			5.5	4.6	4.9	5.2
Muscat Bailey A		3.3	3.2	3.3	3.4	3.1
Himrod	4.2		4.0	4.2		
	Xylem diameter of rachis (mm)					
Kyoho			4.3	3.6	3.0	2.8
Campbell Early			3.8	2.6	2.9	3.0
Muscat Bailey A		2.0	2.0	2.0	1.9	1.9
Himrod	2.4		2.3	2.5		
	Deflection angle (degree)					
Kyoho			3	4	8	15
Campbell Early			3	6	9	10
Muscat Bailey A		49	51	53	46	40
Himrod	63		65	59		

z: Refer to TABLE 4.

TABLE 9. *Effects of Time of GA Treatment on Development of Pedicel in Four Grape Cultivars*

		Date of GA treatment[z]					
		May 27	June 2	June 6	June 16	June 24	July 6
		Pedicel diameter (mm)					
Kyoho	Sd.[y]			-	-	-	5.1
	Sl.			3.9	4.3	4.3	-
Campbell Early	Sd.			3.7	3.7	3.7	3.8
	Sl.			2.8	2.8	-	-
Muscat Bailey A	Sd.		4.8	3.9	3.9	5.1	5.5
	Sl.		2.2	3.0	3.0	2.8	-
Himrod[x]		1.9		1.9	1.9		
		Xylem diameter of pedicel (mm)					
Kyoho	Sd.[y]			-	-	-	2.0
	Sl.			1.5	1.8	1.5	-
Campbell Early	Sd.			1.4	1.3	1.4	1.4
	Sl.			1.0	0.9	-	-
Muscat Bailey A	Sd.		1.7	1.4	1.9	2.2	2.6
	Sl.		0.7	1.1	1.7	1.6	-
Himrod[x]		0.7		0.7	0.9		

z, y, x: Refer to TABLE 4.

3. *Postharvest Berry Drop as Affected by the Time of Harvest.*

With the delay of sampling (harvesting), seedless berries of GA-treated clusters increased their weight similarly with seeded berries of the control clusters (Fig. 2). While, for the former, FRF was low at the earliest sampling and then gradually decreased. However, that of the latter was high at the earliest sampling and decreased suddenly, then gradually, respectively at and after the fourth sampling, being a little higher than that of the former at the last sampling (regular harvesting time) (Fig. 3). TSS increased steadily with the delay of sampling. Throughout the sampling period, it was a little higher for the seedless berries of GA-treated clusters than for the seeded berries of the control clusters (Fig. 4), somewhat different from the results of Exp. 1. In diameters of pedicel and its xylem, no consistent change was found in relation to the sampling dates. However, throughout the sampling period, pedicel diameter was somewhat smaller, while xylem diameter was a little larger for the seedless berries of GA-treated clusters than for the seeded berries of the control clusters (Fig. 5).

4. *Postharvest Berry Drop in Relation to Ethylene.*

When GA-treated clusters were incubated in 80 ppm ethylene, horizontal FRF began to decrease from the first day and reduced to less than half that of the clusters without ethylene treatment on the second day (Table 9). With the reduction of FRF, the percentage berry drop increased and reached 37 and 89 per

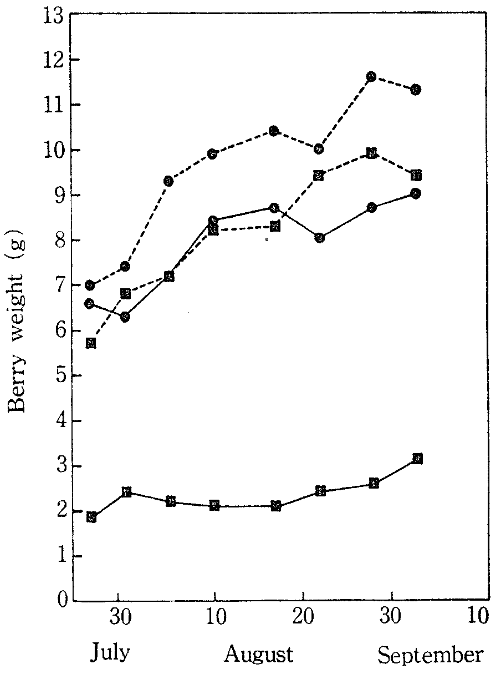

FIG. 2

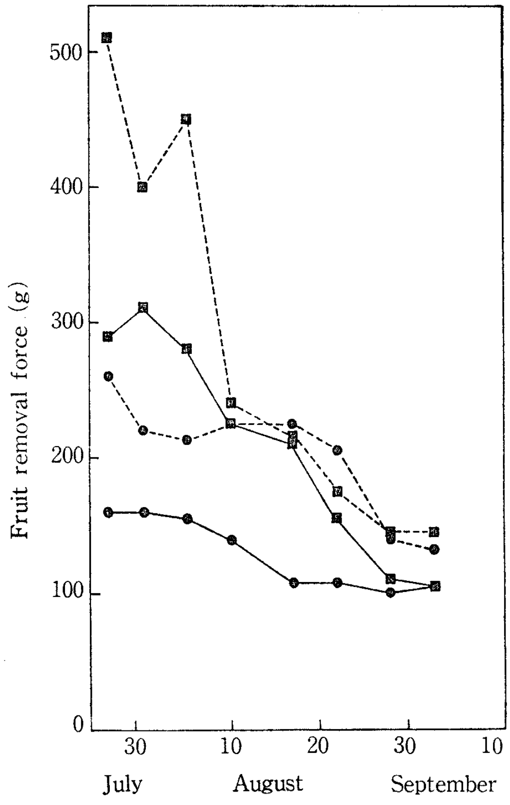

FIG. 3

FIG. 2. Growth in weight of seeded and seedless berries of GA-treated and control clusters. GA-treated, seeded: ●---●, seedless: ●—●, Control, seeded: ■---■, seedless: ■—■, (1978)

FIG. 3. Change in fruit removal force of seeded and seedless berries of GA-treated and control clusters when berry was pushed horizontally. GA-treated, seeded: ●---●, seedless: ●—●. Control, seeded: ■---■, seedless: ■—■, (1978)

TABLE 10. *Effects of Ethylene Treatment on Total Soluble Solid Content (TSS), Fruit Removal Force (Horizontal) and Percentage Berry Drop of GA-treated Clusters in 'Kyoho'*

Days of incuvation	Ethylene treatment	TSS (%)	FRF (g)	% Berry drop
1	Treated	16.4	88	0
	Control	16.6	102	0
2	Treated	17.8	40	37
	Control	18.2	98	3
3	Treated	16.6	-	89
	Control	17.8	97	0

cent on the second and third days, respectively. No consistent relationship was found between TSS and the percentage berry drop. The berries abscised by ethylene treatment was separated from their pedicels at the abscission layer. The berries of GA-treated clusters without ethylene treatment were separated from

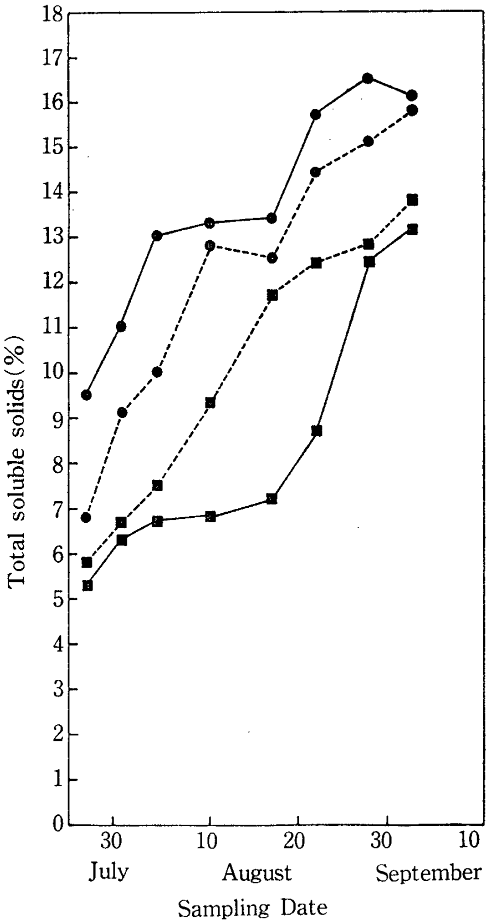

FIG. 4

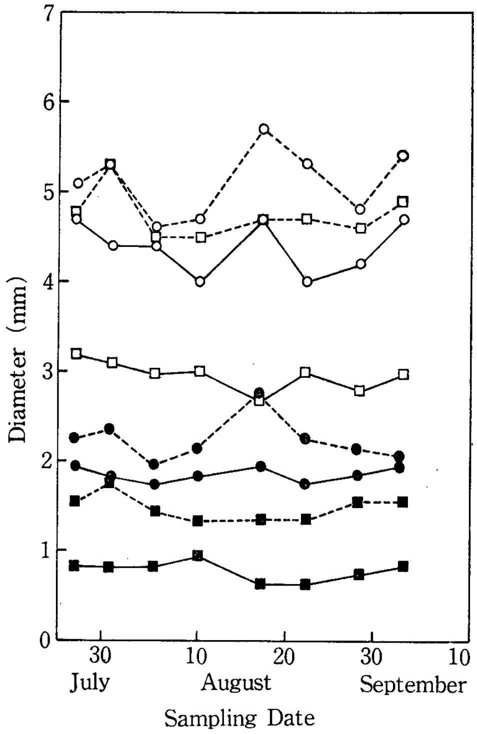

FIG. 5

FIG. 4. Change in total soluble solids of seeded and seedless berries of GA-treated and control clusters. GA-treated, seeded: ●---●, seedless: ●—●. Control, seeded: ■---■, seedless: ■—■. (1978)

FIG. 5. Changes in diameters of pedicel and its xylem of seeded and seedless berries of GA-treated and control clusters. Pedicel diameter; GA-treated, seeded: ○---○, seedless: ○—○, Control, seeded: □---□, seedless: □—□. Xylem diameter of pedicel; GA-treated, seeded: ●---●, seedless: ●—●, Control, seeded: ■---■, seedless: ■—■. (1978)

the distal end of the pedicel, to which was attached a part of the vascular bundle torn from the inside of the berry.

No evolution of ethylene was detected from GA-treated clusters after 4·2/3 hours of incubation.

Discussion

1. *Postharvest Berry Drop as Affected by GA Treatment and Shoot Vigour.*

Irrespective of shoot vigour, little difference was found in the average berry weight and TSS between the seedless berries of GA-treated clusters and the seeded berries of the control clusters, while horizontal FRF was smaller and the percentage berry drop was twice to three times as large for the former than for the latter. In addition, the higher values of percentage berry drop in GA-treated clusters were accompanied with larger diameters of pedicel and its xylem as well as increased hardness and diameter of rachis.

Moreover, as far as GA-treated berries were concerned, little or no difference was found in the number of berries per cluster, average berry weight and TSS between the moderate and vigorous shoots. However, the horizontal FRF was a little smaller and the percentage berry drop was somewhat larger for the vigorous shoots, for which the diameters of pedicel and its xylem as well as rachis hardness and diameter were also larger. For the control clusters, however, no such trend was found in relation to shoot vigour. Thus, it appeared that there was a causal relationship between the increased easiness of berry drop expressed by the higher percentage berry drop and smaller horizontal FRF, and the increased hardness and diameters of rachis and pedicel, as already suggested, though empirically, by Kishi *et al.* (4), Yasunobu (1) and Takahashi *et al.* (2). In addition, the horizontal FRF, rather than the vertical one, seemed to be a more suitable index of easiness of berry drop. The vertical FRF was not necessarily well correlated with the percentage berry drop in relation to the effect of GA, although, in Montmorency cherries, it was highly correlated with the percentage of fruit removal by standard shaking procedure in mechanical harvest (5).

2. *Postharvest Berry Drop in Relation to Berry Maturity.*

When four cultivars differing in easiness of berry drop were compared, berry maturity expressed by TSS was hastened by the earlier GA treatments regardless of cultivars. Moreover, with berry maturity, FRF decreased in 'Kyoho' and 'Campbell Early', but varied little in 'Muscat Bailey A' and 'Himrod'. This was also true for the hardness of rachis, which was increased by the earlier treatments in the former, but little affected in the latter. In addition, in 'Kyoho', FRF of the GA-induced seedless berries was markedly lower than that of the seeded berries of the control clusters as early as 37 days before the regular harvesting time. The difference was evidently larger than expected from the difference in TSS, which was a little higher for the former than for the latter, somewhat different from the results of Exp. 1. From these results, it appeared that the increased hardness of rachis, and perhaps of pedicel, which was often accompanied with an increase in diameters of rachis, pedicel and their xylems, was an important factor in the postharvest berry drop hastened by GA treatment. The berry maturity, which was perhaps related to the softening of berry tissues, was not directly involved in the GA-induced berry drop.

3. *Postharvest Berry Drop in Relation to Ethylene.*

When GA-treated clusters were incubated in 80 per cent ethylene, horizontal FRF decreased from the first day and berry drop was hastened, reaching 89 per cent on the third day. Following ethylene treatment, the berries were separated from their pedicels at the abscission layer. This situation differed from that of the berries abscised by GA alone, where a part of the vascular bundle was torn off with the pedicel from the inside of the berry.

Aoki *et al.* (6) reported, with 10 cultivars, that there was a close relationship between ethylene evolution and the easiness of berry drop, which was increased by 100 ppm ethylene. In our experiment, however, no evolution of ethylene was detected from GA-treated clusters, although the incubation period was as short as 4·2/3 hours. According to Coombe and Hale (7), the concentration of ethylene in the berries of 'Dradillo' grapevines was low at the middle stages of berry growth and decreased still further with berry maturity. They also pointed out that ethylene concentration in grapes was remarkably low as compared with cherries, one of the typical non-climacteric fruits. Ethylene evolution from grapes by Aoki *et al.* was in the order of nl/kg/hr, which was too low as compared with the order of μl/kg/hr in apple (8). Thus, it seemed unreasonable to argue the difference among cultivars in the easiness of berry drop on the basis of ethylene evolution varying in an extremly low order. Our results indicated no participation of ethylene in the postharvest berry drop hastened by GA treatment.

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